INSTRUCTION MANUAL

WITH

SCHEMATIC

FOR

NRI 2500

GOS-3310

S300A

CIE-3310

SINGLE TRACE -TRIGGERED SWEEP

10 MHz OSCILLOSCOPE

TABLE OF CONTENTS

FEATURES

General Description

The CIE-3310 oscilloscope is a general-purpose oscilloscope with features to make it a useful, versatile piece of test equipment offering waveform, frequency, and voltage analysis of frequencies up to 10MHz.

The vertical deflection system offers 4 calibrated ranges from 5mV to 5V/DIV in decade sequence. The vertical VARIABLE control allows continuously variable vertical deflection capability. The input signal may either be capacitively or directly coupled by use of the AC-GND-DC switch.

The horizontal amplifier features 6 calibrated sweep rates from 0.1μS to 10mSec/Div with a sweep VARIABLE control to allow continuous sweep rate variation. The sweep may be internally triggered from the vertical signal or may be externally triggered by a separate input signal. A free-running AUTO mode is provided for sweep without the presence of a triggering signal. A TV triggering mode is offered to aid in stable internal triggering on some television signals.

The horizontal deflection may also be used with an external input to allow frequency and phase comparison between two signals.

The CIE 3310 oscilloscope features a short length 75mm round CRT that allows the scope to be small and lightweight for easy use and minimum space requirement. The screen is covered with a graticule marked 10 units wide and 8 units high for convenience and accurate measurements.

A 1KHz 0.25v square wave is also available on the front panel to allow a quick calibration check of the vertical and horizontal amplifiers as well as probe compensation adjustment.

SPECIFICATIONS

1. Vertical

Sensitivity range

5mV/DIV to 5V/DIV in 4 calibrated decade steps

Frequency range

AC Coupling: 2Hz to 10 MHz
DC Coupling: DC to 10 MHz

Input Impedance

1 Megohm ±5% with less than 35pF

Maximum Input Voltage

600V p-p (DC + AC peak, less than 1 minute and AC freq. less than 1KHz)

2. Horizontal

Sweep Rate

10mS/DIV to 0.1µS/DIV in 6 calibrated decade steps. Accuracy ±5%

External Input

Sensitivity: approximately 0.1V/DIV
Frequency Range: DC to 500 KHz (-3dB)
Input Impedance: 1 Megohm ±5% less than 35pF
Maximum Input Voltage: 600Vp-p (DC+AC Peak)
X-Y phase difference 3° or less at 10KHz

Triggering

Internal Sensitivity: 0.5 DIV from 30 Hz to 2MHz
1.5 DIV from 2MHz to 10 MHz

External Sensitivity: 0.5Vp-p from 30Hz to 2MHz
1V p-p from 2MHz to 10MHz

External Trigger Input: Max. input Voltage: 600V p-p (DC + AC peak)
Input impedance 1 Megohm ±5% with less than 35pF shunt capcitance

3. Amplitude calibrator

Output voltage: 0.25Vp-p square wave ±3%
Repetition Rate: 1KHz ±5%

4. Cathode Ray Tube

Display Area: 75mm round screen
Graticule: 8 DIV x 10 DIV (6mm/DIV)
Accelerating Potential: Approx. 1.3KV

5. Power Requirements

Line Voltage: AC 110/220V -10%
Line Frequency: 50-60 Hz
Power Consumption: Approx. 15W

6. Dimensions and Weight

Dimensions: 202mm Wide x 160mm High x 305 mm Long
7 3/4 in. Wide x 6 1/8 in. High x 12 1/8 in. Long
Weight: Approx. 4.3kg (9½ lb.)

PANEL CONTROLS AND FUNCTIONS

1. POWER Switch: Turns oscilloscope on when in the ON position

2. Pilot Lamp: Lights red when power is supplied and turned on to the oscilloscope.

3. 0.25V CALIBRATOR: Provides a square wave signal of approximately 0.25V p-p at 1KHz for frequency compensation of the input probe and frequency calibration check.

4. LEVEL Control: Rotation performs trigger LEVEL adjustment and push-pull action changes SLOPE of triggering + or -.

   LEVEL: Rotation of this control adjusts the voltage level of the input signal on which triggering takes place. CCW rotation (-) causes a more negative voltage point triggering and CW (+) rotation causes a more positive voltage point triggering.

   SLOPE: The sweep is triggered on the positive-going slope of the triggering waveform when the switch is pushed in and on the negative-going slope of the triggering waveform when the switch is pulled out (PULL, SLOPE (-)).

5. SOURCE Selector Switch: Selects the source of the trigger signal.
   INT: The trigger signal is derived from the displayed waveform.
   EXT: The trigger signal is derived from a separate signal applied to the EXT. INPUT jack.

6. TRIG. MODE Selector
   Selects the operating mode for the trigger circuit.
   AUTO: Automatically provides sweep triggering in the absence of an input signal (free run). Provides triggered sweep operation to some degree when an input signal is present.
   NORM: The sweep will not start without an input trigger signal. This is the normal triggerered sweep mode.
   TV: The input signal is filtered before being fed to the triggering circuits to provide more stable triggering on some television video signals.

   X-Y: This position of the switch disconnects the sweep circuits and allows a signal to be applied to the horizontal circuits from the EXT INPUT jack.

7. TIME/DIV Selector:
Selects calibrated horizontal sweep rates from 0.1 S/DIV to 10m S/DIV in 6 decade ranges when the sweep VARIABLE control is in the CAL position.

8. Sweep VARIABLE:
Varies the sweep rates to values between the settings of the TIME/DIV Selector. Sweep rates are CALIBRATED when this control is rotated fully clockwise.

9. Horizontal POSITION Control:
This will move the display left or right.

10. VOLTS/DIV selector:
This varies the vertical deflection height of an input voltage. It provides 4 decade ranges from 5mV/DIV to 5V/DIV when the vertical VARIABLE control is in the CAL position.

11. Vertical VARIABLE control:
This varies the vertical deflection height between the settings of the VOLTS/DIV selector. The vertical deflection is calibrated when this control is in the fully clockwise CAL position.

12. Vertical POSITION control:
Allows movement of the display up or down.

13. INPUT connector:
This is where vertical input signals are applied.

14. AC-GND-DC selector:
Selects the input coupling mode
AC: Vertical input is capacitively coupled so that the DC component is blocked.
GND: Connects the input to the vertical amplifier to ground for an interference-free reference display. In this position the vertical input jack is disconnected.
DC: The input signal is directly coupled to the vertical amplifier and both AC and DC input will cause vertical deflection.

REAR PANEL CONTROLS

15. INTENSITY Control:
    Used to adjust the brightness of the display. The display becomes brighter when the knob is rotated clockwise.

16. FOCUS Control:
    Adjusts the focus of the trace or spot.

17. EXT INPUT Connector:
    Input jack for external horizontal input or external trigger.

GENERAL EQUIPMENT SAFETY

In order to test electrical and electronic equipment, it is often necessary to remove protective cabinets and coverings, thus exposing voltages capable of producing electrical shock if contacted by the technician.

An electrical shock resulting in 10 milliamperes of current passing through the human heart area can cause the heart to stop beating. Current from one body extremity to another can pass through the heart and produce this hazard. Working with one hand while standing or sitting on an insulated surface significantly reduces this risk. Voltages as low as 35 Volts DC or AC can produce lethal current under certain conditions. Higher voltages can even more easily produce lethal current in the body. Following the safety rules below will significantly reduce the possibility of fatal shock.

1. Don't expose yourself to high voltages unnecessarily. Remove protective housings and covers only as necessary. Don't make test connections when the circuit is energized. Discharge high-voltage capacitors after equipment is de-energized.
2. Try to use only one hand when making adjustments on live circuits. Avoid inadvertent contact with any parts of the equipment because certain faults may cause high voltages to be present at unexpected locations.
3. Work in an area with dry insulative floor material if possible or use a large mat of insulating material to stand on or put under your chair and feet. If equipment is moveable, place it on an insulated surface while servicing it.
4. When using a probe, touch only the insulated portion.
5. Know the circuits you are working on and avoid areas of especially high voltages. Remember that line voltages may be present in some places even with the equipment turned off.
6. Metal parts of equipment with two-wire AC power cords, even with polarized plugs, may not be at ground potential. This not only presents a shock hazard but also may cause test equipment damage if chassis potentials are different. On two wire equipment it is a good idea to use an isolation transformer in the AC supply.
7. Never work alone. Someone trained in CPR first aid should be close enough to render aid if necessary.

SPECIAL SAFETY NOTES
ABOUT YOUR OSCILLOSCOPE

1. Operation of this scope with the cover removed exposes voltages as high as 1500 volts. Applicable safety precautions for working around high voltages must be observed.
2. Be sure that the ground prong of the AC power cord is properly grounded. Defeating this feature by use of an improperly-connected adapter or non-grounded extension cord or other means may pose a potential shock hazard.
3. When the oscilloscope is used to measure line signals, special precautions are required. Do not connect the input lead grounding clip to either side of the line. The clip is already connected through the scope line cord to earth ground, which is common to one side of the line. It may not be readily apparent which side is common, and connecting the ground clip to the wrong side of the line will result in a "short circuit". Bear in mind that many buildings (especially residential) may not be correctly wired.

Precautions to Protect Your Oscilloscope

The following precautions will help prevent scope damage

1. This scope is designed to be operated on nominal line voltage of either 100-120V or 200-240V at 50 or 60 Hz depending on how the internal circuit connections are made. Make sure the scope is set up to use your particular line voltage. Also, the internal line fuse should be 0.5A for 100-120V operation and 0.3A for 200-240V operation. To change the operating voltage see the calibration and adjustment section of this manual.
2. Never allow a small spot of high brilliance to remain stationary on the screen for more than a few seconds. The phosphor of the screen may become permanently damaged in that spot. Either reduce the intensity so the spot is barely visible, de-energize the scope, apply a signal, or place the scope in auto sweep mode. To assure good phosphor life of the CRT it is always advisable to use minimum adequate intensity.
3. Do not appply excessive voltages to the scope input jacks. The maximum ratings of all inputs is 600Vp-p (DC + AC peak) or 212V AC RMS.
4. Never apply an external voltage to the CAL output terminal.
5. Always connect a cable from the ground terminal of the oscilloscope to the chassis of the equipment being tested. Make sure the chassis' are not at different potentials before attaching the ground. If only the probe ground clip is used, there is a possibility of drawing power through the probe ground clip, which could pose a safety hazard in certain circumstances.
6. Do not place objects on top of the oscilloscope or otherwise obstruct the ventilation of the case. This may cause excessvie internal temperatures and premature component failure.
7. Avoid the following operating conditions:
    a. Direct sunlight
    b. High working environment temperature and humidity
    c. Vibration or mechanical shock
    d. Operation near high-voltage or high-current electrical equipment
    e. Operation near strong magnetic fields

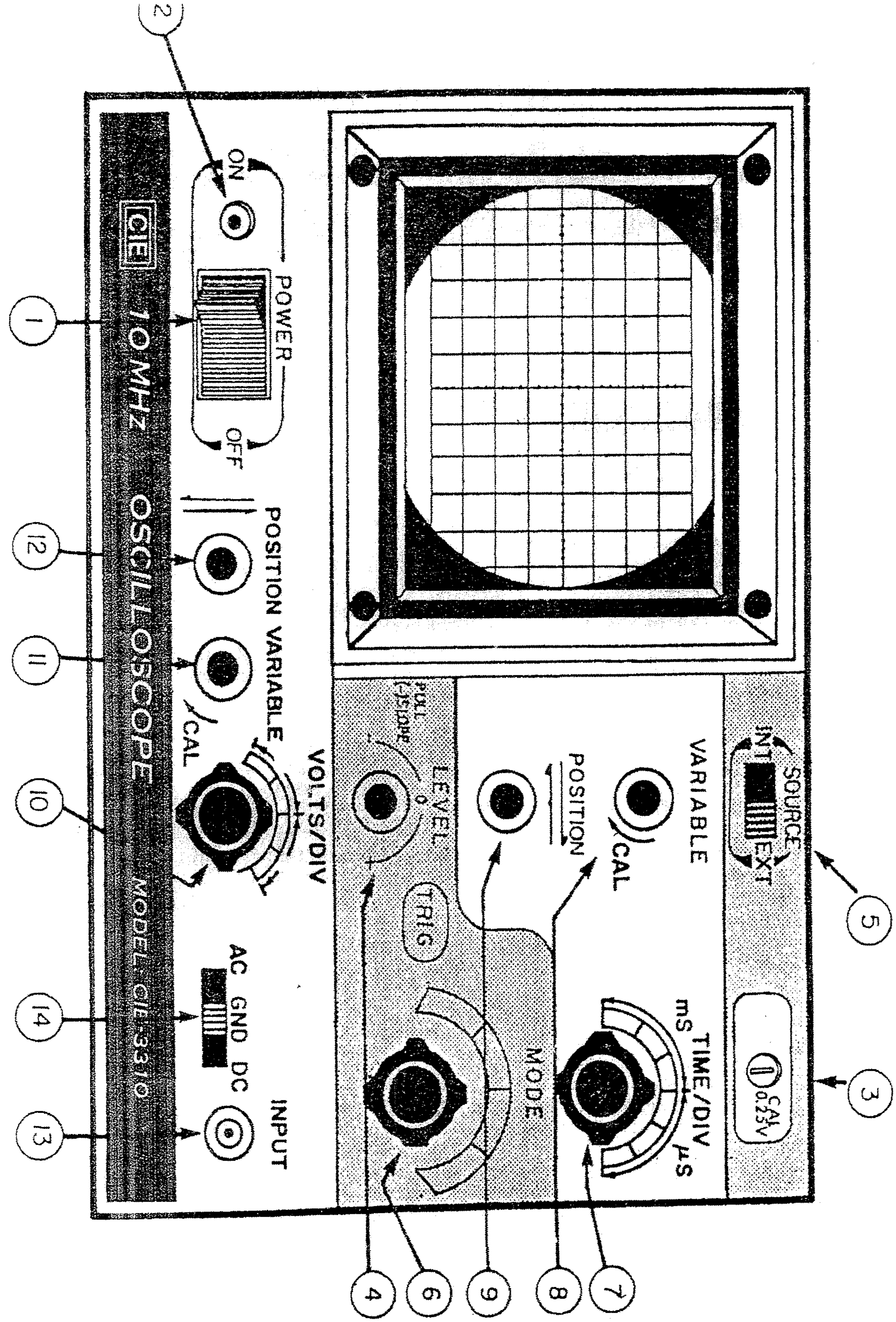


Fig. 1 Front of oscilloscope

GENERAL OPERATION

1. Initial Set-Up
   1. Familiarize yourself with the control locations and functions given in the panel controls and Functions section in the front of this manual.
   2. To obtain a basic sweep display (numbers in parentheses indicate numbered positions on Fig. 1 and 2)
      1. Plug the AC power cord into a properly grounded outlet. See the precautions section concerning outlets.
      2. Move the POWER switch (1) to the ON position. The red LED indicator (2) should light; if it fails to light check that there is power to the outlet you are using.
      3. Allow at least 20 seconds for warm-up of the CRT, then set the front panel controls as follows: .
         - INTENSITY control (15) fully clockwise
         - AC-GND-DC switch (14) in GND position
         - POSITION (12) (vertical position control) in approximate center
         - POSITION (9) (horizontal position control) in approximate center
         - TIME/DIV selector (7) in 1mS position
         - MODE selector (6) in AUTO Position
         - Sweep VARIABLE Control (8) fully clockwise
      4. If a straight line trace is not visible, move the ⇅POSITION (V.POSITION) control (12) clockwise or counterclockwise until it is visible.
      5. Adjust the ⇄ POSITION (H.POSITION) control (9) so that the sweep line starts at the left-most vertical graticule line. Use these control positions whenever a basic sweep display is desired.
   3. To obtain a basic signal waveform display:
      1. Set the scope controls for a basic sweep display.
      2. Observe applicable precautions and connect the signal to be observed to the INPUT connector (13).
      3. Set the VOLTS/DIV switch and the VARIABLE control until the trace is of the desired height.
      4. Set the TIME/DIV switch and the sweep VARIABLE controls until the desired portion of the waveform is displayed.
2. Using Different Triggering Modes
   1. SOURCE of triggering

      With the SOURCE selector (5) in the INTERNAL position the triggering signal is derived from the signal being displayed. If the SOURCE selector is in the EXTERNAL position the triggering pulse is derived from a signal input to the EXTERNAL INPUT jack on the back of the scope (17 in Fig. 2).

      The triggering mode functions with the SOURCE switch in EXT are the same as given above, except that triggering does not take place because of the observed waveform. The LEVEL control functions the same on an external trigger input as it does on internal.

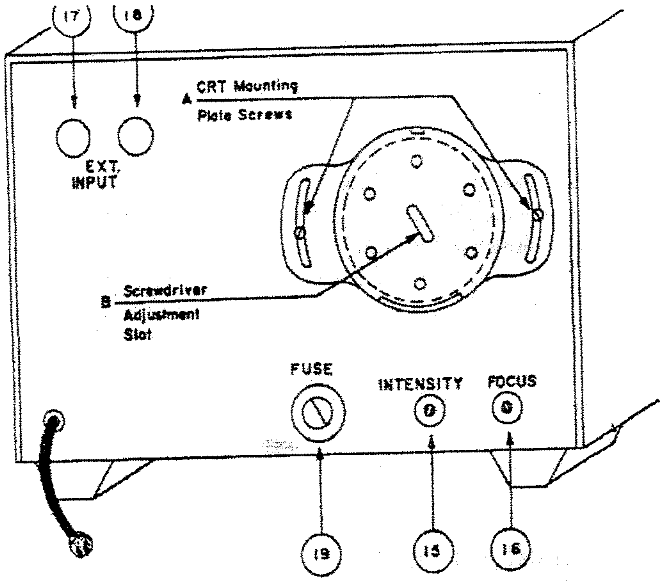


Fig. 2 Rear of oscilloscope

2. <u>LEVEL control</u> - See NORMAL triggering mode.

3. <u>AUTO triggering</u>

In this mode the sweep is automatically internally triggered in the absence of a triggering signal. It will synchronize to a triggering signal and it may be triggered on either the positive or negative going slope of the incoming vertical signal by pushing or pulling the LEVEL control (4), however the actual LEVEL control rotation has no effect on the triggering point. The AUTO mode will function if the SOURCE is in either INTERNAL or EXTERNAL.

4. <u>NORMAL triggering mode with SOURCE switch in INT.</u>

To use normal triggering mode, apply a vertical input signal to the INPUT connector (13). Set the scope controls for a basic signal display. Set the MODE switch to the NORM position. The voltage level of the displayed waveform that triggers the horizontal sweep is now controlled by the LEVEL control (4). If the input is a sine wave, the function of the LEVEL control is shown in Fig. 3.

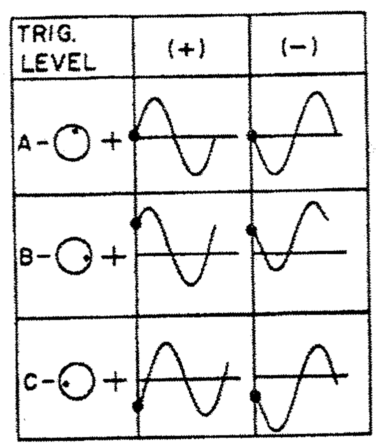


Fig. 3 Effects of triggering LEVEL control

With the LEVEL control pushed in (column (+) in Fig. 3) the trigger will occur on the positive-going portion of the waveform. When the LEVEL control is pulled out, the trigger will occur on the negative-going slope of the waveform (column (-) in Fig. 3). When the LEVEL control is moved clockwise, the triggering point will move more positive on the waveform (line B on Fig. 3). If the LEVEL control is turned counterclockwise, the triggering point will move more negative on the waveform (line C on Fig. 3). The display must be at least one division high to obtain proper triggering. Turning the trigger LEVEL control to the extremes may cause the trigger level to be set beyond the voltages of the displayed signal, which will result in cessation of the sweep.

In the normal trigger mode, the horizontal sweep will not begin without a trigger. Once the sweep is triggered, it will make one sweep at the rate set by the TIME/DIV and the sweep VARIABLE control, then it will wait for the next trigger pulse.

5. TV triggering mode

A television video signal contains several frequencies. It may be difficult to get a stable triggered display in the NORM mode because triggering may take place on different signal components from sweep to sweep. The TV mode filters out some of the signal components to provide more stable triggering. This mode is functional on both internal and external trigger sources.

6. X-Y position of the MODE Selector

This is not a triggering mode. When the MODE selector switch is in the X-Y position, the sweep circuits are disconnected from the horizontal amplifier and an external signal may be applied to the horizontal circuits through the EXT INPUT (17 on Fig. 2). For use of this function see the procedure on relative measurements in this instruction manual.

APPLICATIONS

1. DC Voltage Measurement

(Signal within one of the VOLTS/DIV ranges.)

1. Connect the signal to be measured to the vertical INPUT jack. Use the X10 probe if the voltage to be measured is higher than 40 Volts p-p, or refer to the section covering signals not within one of the VOLTS/DIV ranges. Be sure to observe input voltage limitations.

2. Set the scope controls to obtain a good waveform display, or, if the signal is DC, a sweep line display. Set the VOLTS/DIV Control to a value to show a measureable height of display on the screen. The vertical VARIABLE control should be fully clockwise CAL position. A voltage of 15V to 40V may be displayed on the 5V/DIV range, 1.5V to 4V on the 0.5V/DIV range, 150mV to 0.4V on the 50mV range, and 15mV to 40mV on the 5MV/DIV range. Each of these ranges may be multiplied by 10 if a X10 probe is used. If the voltage to be measured is not within one of these ranges, refer to the section concerning signals not within one of the VOLTS/DIV ranges.
3. Place the INPUT switch in the GND position.
4. Adjust the V. POSITION control so that the base level line is on one of the vertical graticule divisions low enough to allow vertical display of the entire signal to be measured. Do not disturb this setting while measurement is being made.
5. Move the AC-GND-DC Switch to the DC position and note the sweep line displacement for a DC signal (see Fig. 4) or total signal height to the level where measurement is desired. (see Fig. 5) A vertical displacement of at least 3 divisions is suggested for optimum accuracy of measurement. The reference level may be re-checked by returning the AC-GND-DC switch to the GND position.

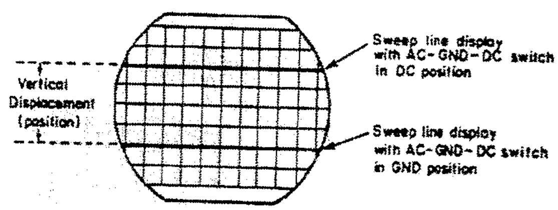


Fig. 4 DC voltage measurement

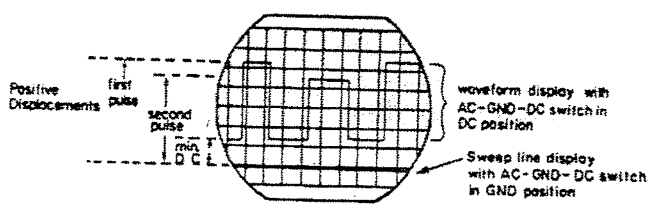


Fig. 5 DC level of waveform measurement

6. Calculate the displayed voltage by multiplying the number of divisions of vertical displacement times the setting of the VOLTS/DIV switch times the probe attenuation factor. For example for Fig. 4 if the VOLTS/DIV switch were set to 0.5V/DIV and the X10 probe used, the displayed voltage would be 5 DIV X 0.5V/DIV X 10 (probe factor) = 25 volts.

2. Peak-to-Peak Voltage Measurements

(Voltage displayable using one of the VOLTS/DIV ranges)

1. Connect the signal to be measured to the vertical INPUT jack. Be sure to observe input voltage limitations. Set up the scope to obtain a good waveform display with the AC-GND-DC switch in the AC position. Set the vertical VARIABLE control fully clockwise to the CAL position. If the waveform cannot be adequately displayed because it's too high on one VOLTS/DIV scale and too low (less than 3 divisions vertical deflection) on the next lower VOLTS/DIV ranges, then see the procedure for voltage not within one of the VOLTS/DIV ranges.
2. For optimum measurement, the portion of the waveform to be measured should be as centered as possible both horizontally and vertically.
3. Adjust the V. POSITION control until the lowest point of the waveform falls on one of the horizontal graticule lines, keeping the waveform as close to being centered as possible. (see Fig. 6)

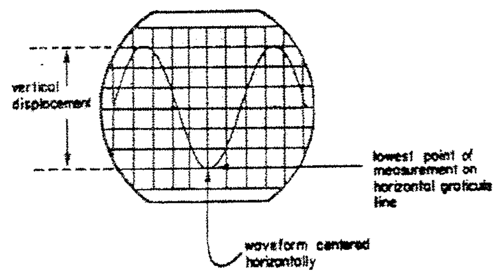


Fig. 6 Peak-to-peak voltage measurement

4. Note the number of divisions of vertical displacement between the upper and lower points of the waveform where measurement is desired, and multiply this times the setting of the VOLTS/DIV selector times the probe attenuation factor.

For example, in Fig. 6 if the VOLTS/DIV selector was in the 5mV/DIV position using the X1 probe then the voltage of the waveform peak to peak would be 6 DIV of vertical displacement times 50mV/DIV x 1 (probe factor)=300mV peak-to-peak.

3. Peak-to-Peak Voltage Measurements

(Voltage measurements when voltage being measured cannot be displayed on one of the VOLTS/DIV selector positions with the vertical VARIABLE fully clockwise)

This added procedure should be used when the vertical deflection obtained from the input signal is too high for the screen on one VOLTS/DIV scale and less than 3 div high on the next lower VOLTS/DIV scale with the vertical VARIABLE control in the fully clockwise CAL position.

1. Set up the scope controls for a normal sweep line display.
2. Connect the X1 input lead to the 0.25V CAL signal on the front panel. (Another reference voltage may be used if higher accuracy is desired)
3. Set the scope controls as follows:
   - Sweep VARIABLE to CAL
   - TIME/DIV to 0.1ms
   - VOLTS/DIV to 50mV
   - V.VARIABLE to CAL
4. The displayed square wave should be about 5 divisions high. 5 divisions times 50mV per divisions times 1 (probe factor) is 250mV or 0.25V. This is not extremely accurate, but it should be ±3%
5. Adjust the vertical VARIABLE control until the square wave is 2.5 divisions high. With the VARIABLE control left in this position, all of the VOLTS/DIV ranges are multiplied by 2. The 5V/DIV range is now 10V per division and the 0.5V/DIV range is now 1.0V/DIV etc., as long as the VARIABLE control is left in this newly-calibrated position. This should be accurate enough to make measurements to within ±10%.
6. With the VARIABLE control left in this position, follow the procedures for AC or DC voltage measurements and multiply the VOLTS/DIV control ranges times 2.

4. <u>Waveform Period Measurements</u>

This procedure can be used to measure the period of a complete waveform, or the duration of any part of a waveform. The period of the waveform can then be used to calculate the frequency.

1. Connect the signal to be measure to the INPUT jack.
2. Set the scope controls to obtain a good display of the waveform with the sweep VARIABLE control in the fully clockwise CAL position. Be sure that the complete section of the waveform that you want to measure is displayed on the screen at least once. If the waveform section to be measured is too long on one TIME/DIV scale and too short (less than 3 div.) on the next higher TIME/DIV scale, see the procedure for temporarily recalibrating the sweep ranges and then return to this procedure.
3. Move the H. POSITION control until the front part of the waveform section to be measured is on a vertical graticule line. (see Fig. 7)
4. If accurate waveform frequency or period measurement is to be made, center the waveform vertically. The complete period must be measured from one point or the beginning of the waveform to the same point beginning the next waveform. (see Fig. 8)
5. Note the number of horizontal divisions of the period being measured.
6. Calculate the period by multiplying the number of horizontal divisions of the measured period times the setting of the TIME/DIV Selector.

For example, the period of the pulse in Fig. 7 is 3.75 divisions. If the TIME/DIV Selector is in the 1mS/DIV then the period is 3.75 divisions x 1mS/DIV=3.75mS.

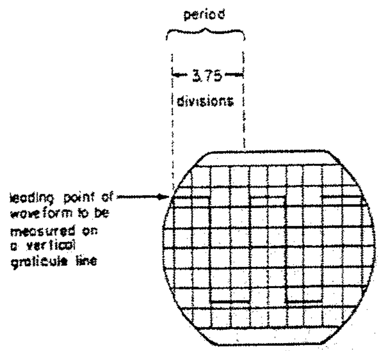


Fig. 7 Square wave period measurement

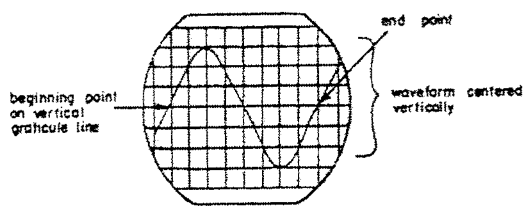


Fig. 8 Sine wave period measurement

7. For frequency measurement, multiply the number of horizontal divisions covered by one complete cycle times the TIME/DIV switch setting. That gives the period of the wave. To convert to frequency, divide the period into 1.

$$\text{Frequency} = \frac{1}{\text{period}}$$

For example if the VOLTS/DIV setting for Fig. 8 is 0.1mS/DIV then the period is 8 DIV/cycle times 0.1mS/DIV = 0.8mS/cycle. The frequency is then

$$\frac{1}{0.8X10^{-3}} = 1.25X10^{3}\text{Hz or } 1.25 \text{ KHz}$$

5. Out-of-Range Period Measurements

This procuedure can be used if when the sweep VARIABLE control is in the fully clockwise CAL position the waveform is longer than 10 divisions on one TIME/DIV control setting and less than 3 divisions long on the next higher TIME/DIV scale. This general procedure may also be used to compare the period of an unknown frequency to a standard.

1. Connect the vertical INPUT to the 0.25V CAL terminal using the X1 input probe. (another reference frequency may be used if desired)
2. Set up the scope controls for a normal sweep display.
3. Set scope controls as follows:
   -VOLTS/DIV to 50mV position
   -V.VARIABLE to CAL
   -TIME/DIV to .1mS
   -sweep VARIABLE to CAL
4. The displayed square wave should now be 10 divisions long. Since the TIME/DIV control is in the 0.1mS/DIV position the period is 0.1mS/DIV X 10 div/cycle = 1mS/cycle. The frequency is:

$$\text{Frequency} = \frac{1}{1X10^{-3}\text{sec/cycle}} = 1X10^{3} \text{ cycle/sec or 1KHz.}$$

   Note that the accuracy of the CAL signal is ±5%.
5. Move the sweep VARIABLE control until the square wave is 5 divisions long. With the sweep VARIABLE control in this position the time per division of each position of the TIME/DIV switch is doubled. The 10mS/DIV position is now 20mS/DIV, the 1mS/DIV is now 2mS/DIV etc. By leaving the sweep VARIABLE control in this position, period and frequency measurements may be made using the procedures in this manual.

6. Phase Difference Measurement (point-shift method)

This method may be used to determine the phase difference of two sine waves.

1. Set the scope controls to obtain a normal sweep display then set the controls as follows:
   -MODE to NORM
   -SOURCE Selector to EXT
2. Connect the leading signal to both the vertical INPUT jack and the EXT INPUT jack.
3. The scope is now being triggered through the EXT INPUT. This will be the reference signal. Set the scope controls so that one or two sine waves are displayed. It may be helpful to make one cycle an exact number of divisions in length.
4. Position the sine wave so that the center of the sine wave is on the center horizontal graticule line. (see Fig. 9a)
5. Set the H. POSITION control so that the trace begins on exactly the left-most vertical graticule line.

(a) Centered display (b) Shifted display

Fig. 9 Displays for phase difference measurement

6. Set the triggering LEVEL control so that the sine wave begins on the center horizontal graticule line. (see Fig. 9a) Make sure this control remains undisturbed for the rest of this procedure.
7. Leave the leading signal connected to the EXT INPUT (this is the reference signal the scope is triggering on) and disconnect the signal from the vertical INPUT.
8. Connect the lagging signal to the vertical INPUT jack.
9. Note the number of divisions of difference between the starting point of the reference signal displayed previously and this signal (see Fig. 9b).

   The phase angle difference can be calculated by first determining the period of the waveform T. Count the divisions covered by one complete cycle of the waveform. The phase angle can then be calculated using the following equation:

$$\frac{\text{Number of divisions of shift (t) X 360}}{\text{Number of divisions of period (T)}} = \text{phase shift angle}$$

$$\text{or } \frac{360t}{T} = \text{phase shift angle}$$

Remember that the TIME/DIV settings are multiplied by two.

7. Comparative Frequency Measurements and Phase Comparisons

This method can be used to compare two frequencies if they are both sine waves and if one is adjustable in frequency or one is a harmonic of the other, and the signals are somehow synchronized.

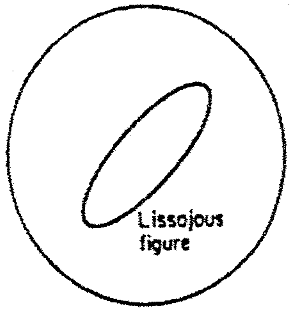
This method can also be used to make a rough phase comparison between two sinusoidal signals.

1. To make a phase or frequency comparison of two signals, connect one signal to the EXT INPUT jack on the rear of the scope. The deflection of this signal is about 0.1V per division and is not externally adjustable on the scope. Therefore, for an acceptable display the input signal must be between about 0.3V and 1V with the X1 input or 3V to 10V with the X10 probe.

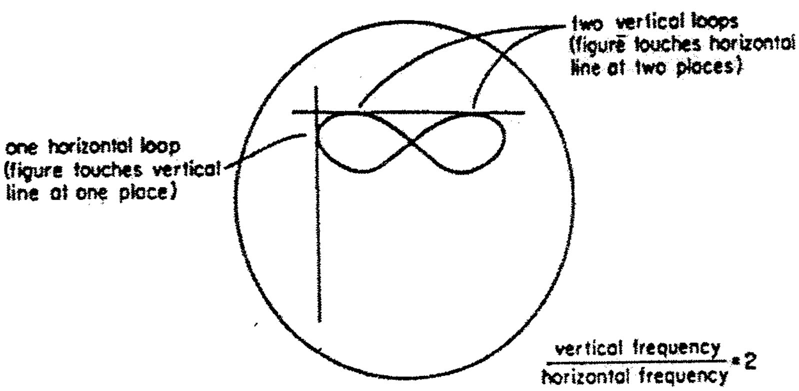
2. Connect the other signal to the vertical INPUT jack on the front pannel.
3. Set the AC-GND-DC switch to AC.
4. Set the MODE selector to EXT.
5. Adjust the VOLTS/DIV selector and the V. VARIABLE for a good display.

For frequency comparison the frequency ratio of vertical to horizontal will be the ratio of the number of vertical loops to the number of horizontal loops. See Fig. 10 for some examples. These patterns will vary as the phase relationship between the signal varies. (see Fig. 11, 12 and 13) If one frequency is adjustable, adjust for the desired ratio and for a stable display.

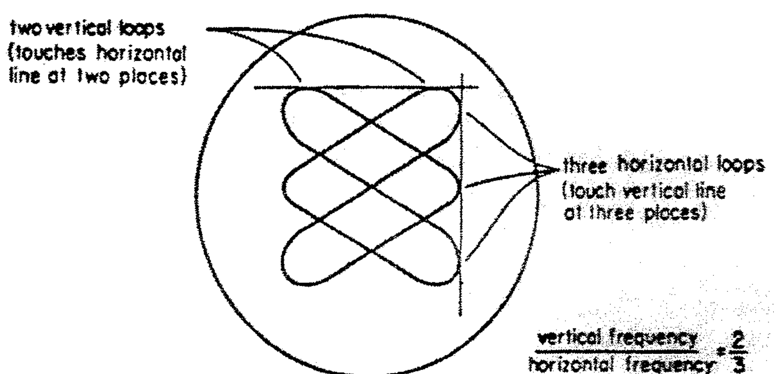
For phase comparison of two signals of the same frequency see Figs. 11 and 12. These figures are for undistorted sine waves. From these figures it is not possible to determine which signal is leading or lagging. To do the phase comparison of Fig. 12, both horizontal and vertical amplitudes must be equal.



(a) Lissajous figure with vertical and horizontal inputs at the samefrequency (out of phase)



(b) Lissajous pattern when the vertical frequency is twice the horizontal frequency



(c) Lissajous pattern when the ratio of vertical frequency to horizontal frequency

Fig. 10 Lissajous patterns for frequency comparisons

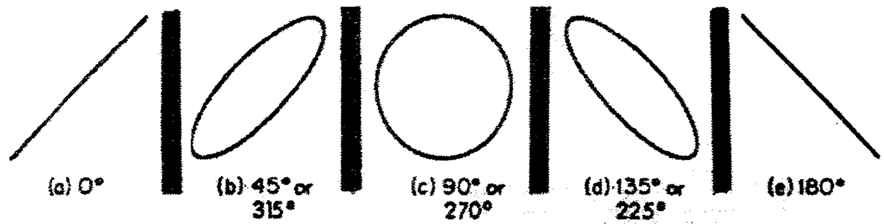


Fig. 11 Lissajous figures for phase difference between vertical and horizontal sine waves at the same frequency

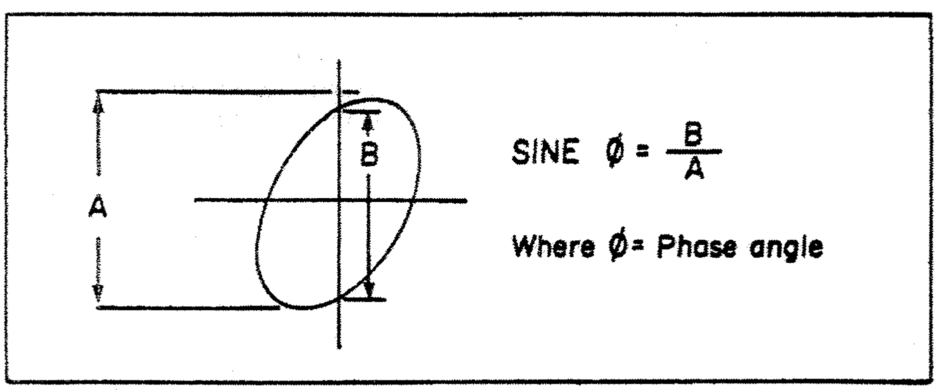


Fig. 12 Lissajous figure phase measurement

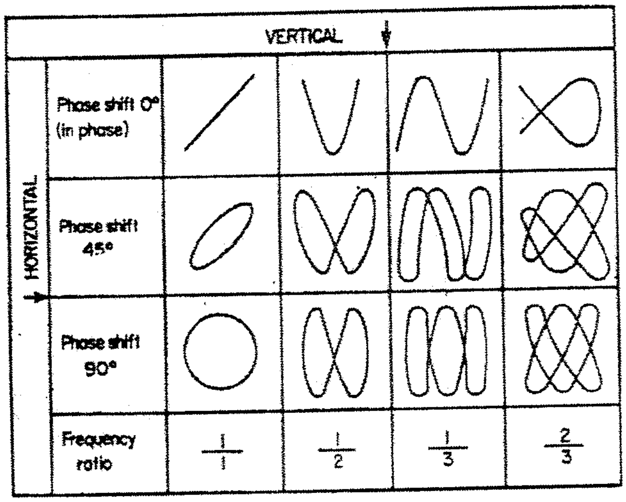


Fig. 13 Lissajous figure phase and frequency comparisons

GENERAL ADJUSTMENTS AND CHECKS

1. Probe Compensation
   1. Connect the 10:1 input probe to the vertical INPUT jack and to the 0.25V CAL terminal on the front of the scope.
   2. Set the scope controls to obtain a good display of 2 or 3 square waves of 4 or 5 divisions amplitude
   3. Adjust the compensation trimmer on the 10:1 probe plug (Fig. 14) for flat tops on the square waves (see Fig. 15)

2. Horizontal Trace Alignment with Graticule

   If the horizontal sweep is not aligned with the horizontal graticule lines, loosen the rear CRT mounting plate screws and rotate the plate until correct alignment is obtained. (see Fig. 2)

3. Quick Calibration Check

   A quick check of horizontal and vertical calibration may be done with the 0.25V CAL signal from the front panel. This is only a rough check, however, because the CAL signal is only ±3% in amplitude and ±5% in frequency. Accurate calibration requires a more accurate signal source.

   To perform the quick check proceed as follows:
   1. Connect the X1 input lead the vertical INPUT jack and to the 0.25V CAL signal on the front panel.
   2. Set the scope controls as indicated:
      - -VOLTS/DIV to 50mV
      - -V.VARIABLE to CAL
      - -MODE selector to AUTO
      - -SOURCE to INT
      - -TIME/DIV to .1mS
      - -sweep VARIABLE to CAL

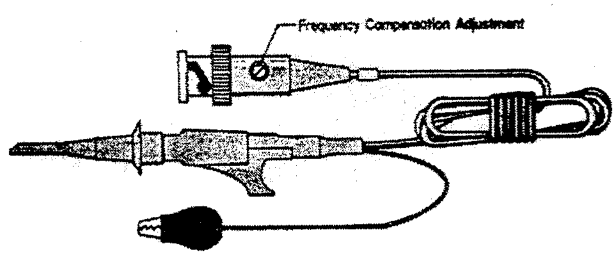
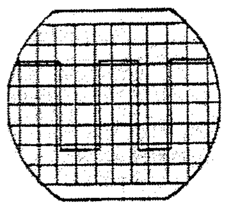
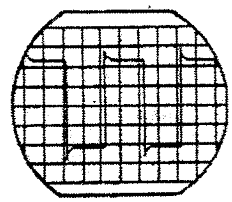


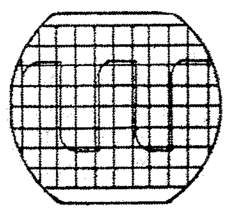
Fig. 14 Frequency compensation adjustment on the 10:1 input probe



(a) Correct compensation



(b) Over compensation



(c) Insufficient compensation

Fig. 15 Frequency compensation waveforms

3. The displayed square wave when properly centered should be 5 divisions high and 10 divisions long (5 divisions positive, 5 divisions negative) (see Fig. 16).

   If the square wave is not 5 divisions high, use an accurate standard to check the vertical calibration procedure contained elsewhere in this manual. If vertical calibration is within tolerance, check the voltage output of the CAL signal and adjust it if necessary according to the procedure contained elsewhere in this manual.

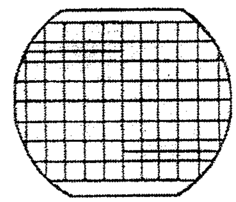


Fig. 16 Calibration signal display

If the square wave is not 10 divisions long, then check the horizontal calibration with an accurate standard and perform horizontal calibration according to the procedure contained elsewhere in this manual. If the horizontal calibration is correct, check the output frequency of the CAL signal and adjust it if necessary according to the procedure given in this manual.

If the negative portion of the square wave is not the same length as the positive portion then a need for adjustment of the CAL signal is indicated.

4. Case Removal

Caution: High voltages up to 1200V are present inside the scope when the unit is in operation. Line voltages are also present in certain locations even when the power switch is off. Remember also that some capacitors may hold a charge for a considerable time after the equipment is de-energized. Be sure to follow all applicable precautions contained in the safety precaution section of this manual. The case should only be removed by qualified service personnel.

To remove the case remove the 10 case screws, 4 on each side and two at the front on the top. The case may then be lifted off.

Caution must also be exercized to assure that no objects strike the CRT. This may result in implosion of the CRT which could propel pieces of glass at high speeds for considerable distances with obvious safety hazards to nearby personnel.

The case must be removed to perform most of the following adjustments with the exception of fuse replacement.

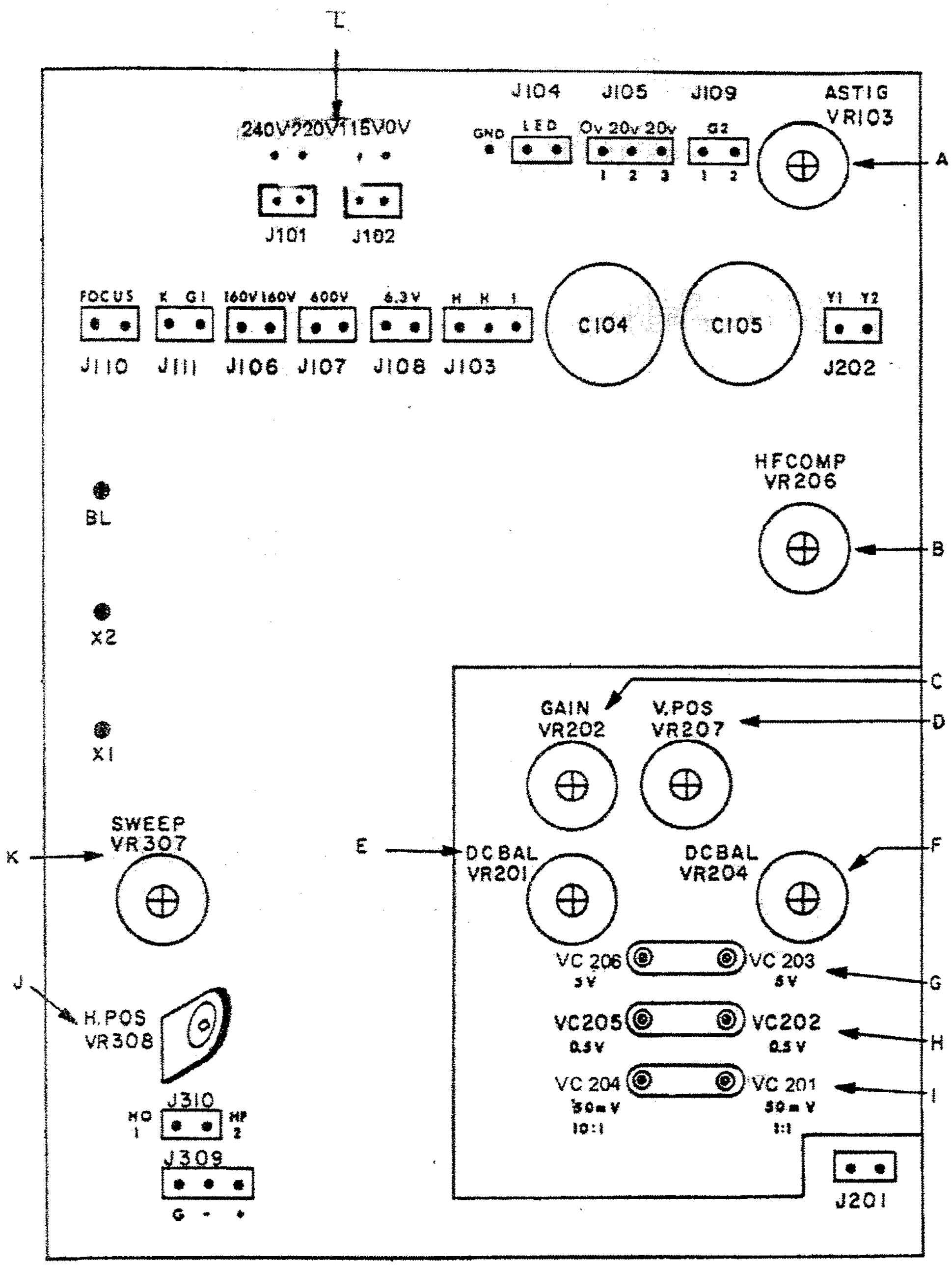


Fig. 17 Main circuit board

5. Fuse Replacement

During normal operation of the scope the fuse should never need replacement. If the fuse is found to be open there is probably a problem with the scope. It should be checked before replacing the fuse. Replace the fuse only with a 0.5A fuse for scopes set to operate on 100-120V or 0.3A for scopes set to operate on 200-240V supply. Fuse location is on the rear panel of the scope. (see Fig. 2 (19))

6. Changing Voltage of Operation

This oscilloscope is capable of being set to operate on either 100-120VAC or 200-240VAC 50 or 60 Hz supplies. To change the operating voltage, jumper wires at the rear of the main circuit board must be moved. (see Fig. 17 (L))

For 115V operation the red wire from the power switch should be plugged onto the pin marked 115V, as shown in Fig. 18.

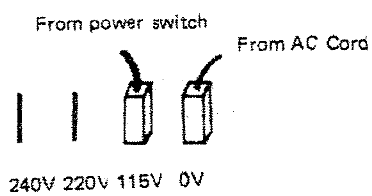


Fig. 18 Connections for 115V AC operation

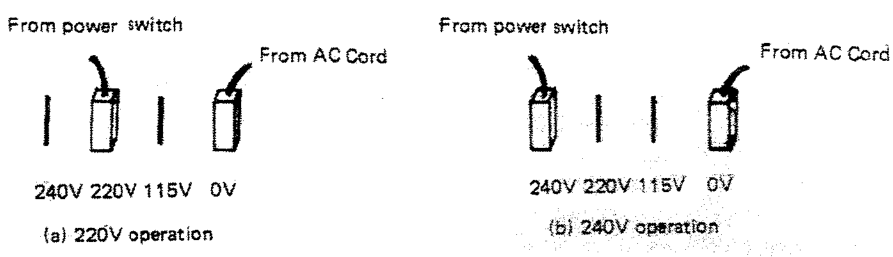


Fig. 19 Connections for 220V or 240V AC operation

For 220V or 240V operation the wire from the power switch should be connected to the 220V pin for 220V operation (see Fig. 19a) or to the 240V pin for 240V operation (see Fig. 19b).

7. Power Supply Voltage Checks

AC line 110V or 220V ±10%
DC ±9V supply ±10%
±15V supply ±10%
+190V supply ±10%
+170V supply ±10%
-1170V supply ±20%

8. Astigmatism Adjustment

Set the AC-GND-DC selector to the GND position and the MODE selector to the X-Y position. Then adjust the ASTIG pot VR103 (see Fig. 17 (A)) and the focus control for the clearest round spot.

VERTICAL CIRCUITS ADJUSTMENTS

1. DC Balance Adjustment
   1. Set the AC-GND-DC selector to GND and the VOLTS/DIV Switch to the 5mV/DIV range.
   2. Adjust the DC BAL potentiometers (pots) VR 201 and VR 204 until the trace does not shift when the V.VARIABLE control is turned. (see Fig. 17 (E) and (F))

2. High Frequency Compensation
   1. Set the VOLTS/DIV switch to 5mV/DIV and connect a 30mV, 100KHz square wave signal of good quality with flat extremes to the INPUT jack.
   2. Adjust HF COMP pot VR206 (see Fig. 17 (B)) so that the display has flat extremes as shown in Fig. 15

3. Vertical Gain Calibration
   1. Connect a 1KHz 25mV p-p square wave to the INPUT jack.
   2. Set the V.VARIABLE control fully clockwise to the CAL position.
   3. Set the VOLTS/DIV switch to the 5mV/DIV position
   4. Adjust the GAIN pot VR202 (see Fig. 17 (C)) so that the observed waveform is exactly 5 divisions high.

4. Vertical Position Centering
   1. Turn the front panel V.POSITION control to approximate center of its travel.
   2. Adjust the internal V.POSITION pot VR207 (see Fig. 17 (D)) to center the trace on the screen.

5. Vertical Frequency Compensation

1. Six frequency compensation trimmers are in the scope, two for each of the vertical deflection ranges 5V/DIV, 0.5V/DIV and 50mV/DIV. VC201 VC202 and VC203 are for direct input compensation (1:1) and VC204, VC205 and VC206 are for compensation using the 10:1 attenuator input probe.

   Optimum compensation is obtained when the V.VARIABLE control is fully clockwise in the CAL position. Since compensation of the 3 vertical ranges is necessary, square waves of different amplitudes will be necessary. The square waves should be at a frequency of 1KHz and be of good quality with flat amplitude extremes.
2. For 1:1 compensation of the 50mV/DIV range connect a 1KHz square wave with an amplitude of between 0.2V and 0.4V to the vertical INPUT jack using the direct probe. Set the scope controls to display two or three cycles of the square wave. (see Fig. 15)
3. Adjust VC201 (see Fig. 17 (I)) for flat extremes on the square wave. See Fig. 15 for representative waveforms.
4. For 1:1 compensation of the 0.5V/DIV range connect a 1KHz square wave with an amplitude between 2V and 4V to the vertical INPUT jack using the direct probe. Set the scope controls to display two or three cycles of the square wave.
5. Adjust VC202 (Fig. 17 (H)) for flat extremes on the square wave. See Fig. 15 for representative waveforms.
6. For 1:1 compensation of the 5V/DIV range connect a 1KHz square wave with an amplitude between 20V and 40V to the vertical INPUT jack using the direct probe. Set the scope controls to display two or three cycles of the square wave.
7. Adjust VC203 (Fig. 17 (G)) for flat extremes on the square wave. See Fig. 15 for representative waveforms.
8. For 10:1 compensation use the 10:1 attenuator probe and repeat steps 2 through 7 above multiplying the required square wave input amplitude by 10 and adjusting VC204 for step 3, VC205 for step 5 and VC206 for step 7.

HORIZONTAL CIRCUIT ADJUSTMENTS

1. Horizontal VARIABLE Range Adjustment
   1. Set the TIME/DIV switch to 0.1mS/DIV and apply a marker signal or sine wave of 1 mS duration to the INPUT jack.
   2. Rotate the H.VARIABLE control fully clockwise to the CAL position.
   3. Adjust the SWEEP calibrate pot VR307 (see Fig. 17 (K)) until one cycle of the displayed waveform is exactly 10 divisions long.
   4. Turn the H.VARIABLE control fully counterclockwise.
   5. Adjust the variable range pot VR303 on the front control panel circuit board until there are 12 cycles of the displayed waveform within the 10 divisions of the graticule.

2. Time Base Calibration
   1. Set the TIME/DIV switch to the 1mS/DIV range and apply a marker signal or sine wave of 1mS duration to the INPUT jack.
   2. Rotate the H.VARIABLE control fully clockwise to the CAL position.
   3. Re-adjust the SWEEP calibrate pot VR307 (see Fig. 17 (K)) until 10 cycles of the displayed waveform are exactly 10 divisions long.

3. Horizontal Position Adjustment
   1. Connect a 1KHz sine wave to the INPUT jack.
   2. Adjust the internal H.POSITION pot VR308 (see Fig. 17 (J)) so that when the front panel H.POSITION control is rotated from fully clockwise to fully counterclockwise the distances A and B shown in Fig. 20 are the same.
   3. Note: this adjustment will change the external horizontal position adjustment.

(a) H.POSITION control rotated fully clockwise

(b) H.POSITION control rotated fully counterclockwise

Fig. 20 Horizontal position centering

4. <u>External Horizontal EXT Sensitivity and Position Adjustments</u>

1. Set the AC-GND-DC switch to GND.
2. Set the MODE switch to X-Y, and apply a 1KHz 1V p-p sine wave to the EXT input jack.
3. If the displayed line is longer or shorter than 10 divisions, then adjust the EXT GAIN pot VR309 (see Fig. 21) clockwise to increase the length of the display and counterclockwise to decrease its length. This adjustment will cause the display to shift right or left so adjust the H. POS. pot VR301 until the display line is centered again.

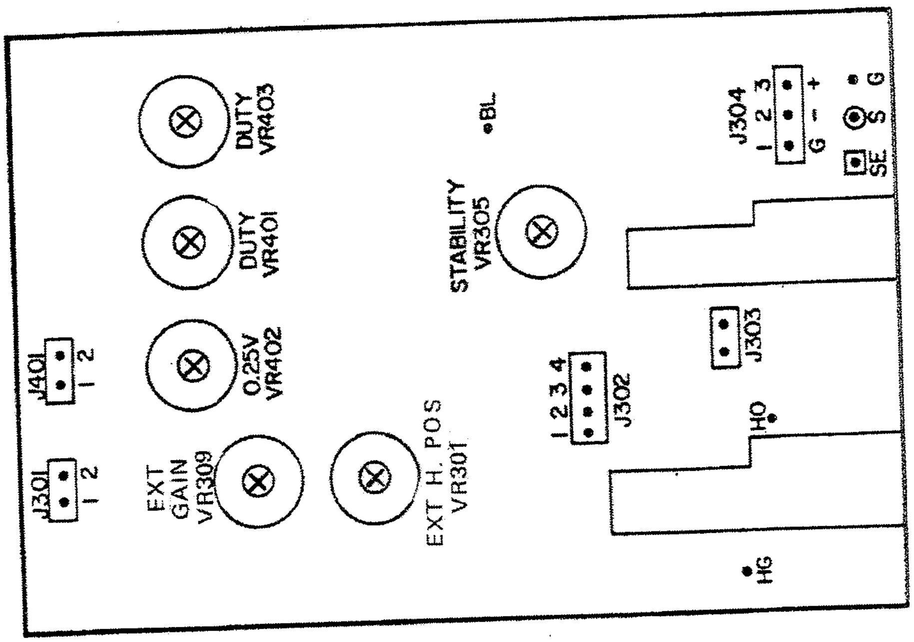


Fig. 21 Triggering and horizontal sweep board

4. Repeat these adjustments until the display line is exactly 10 divisions long.
5. Once this adjustment is made, remove the 1KHz signal and rotate the front panel H.POSITION control clockwise and counterclockwise to see if the spot will move equal distances left and right so that distances A and B as shown in Fig. 22 are equal. If the spot does not move equal distances, adjust H. POS pot VR301 until it does.

5. <u>Triggering Stability Adjustment</u>

1. Set the MODE switch to AUTO
2. Set the TIME/DIV switch to the 10mS/DIV range.
3. Apply a 30Hz sine wave to the vertical INPUT and set the VOLTS/DIV and V.VARIABLE controls so that there is 0.5 divisions vertical height of the display.
4. Set the MODE selector to NORM.

(a) H.POSITION control rotated fully clockwise

(b) H.POSITION control rotated fully counterclockwise

Fig. 22 External horizontal position centering

5. Rotate the LEVEL control fully clockwise.
6. Temporarily connect a 330K resistor in parallel with R343 (see Fig. 21).
7. Adjust the STABILITY pot VR305 clockwise until there is a signal display, then turn it counterclockwise just to the point where the sweep stops leaving a 0.5 division high vertical line.
8. Remove the 330K resistor. This should set the triggering sensitivity within the specifications given in Table I.

INT	0.5 Div. on screen, 30 Hz to 2 MHz
	1.5 Div on screen, 2 MHz to 10 MHz
EXT	0.5Vp-p, 30 Hz to 2 MHz
	1Vp-p, 2 MHz to 10 MHz

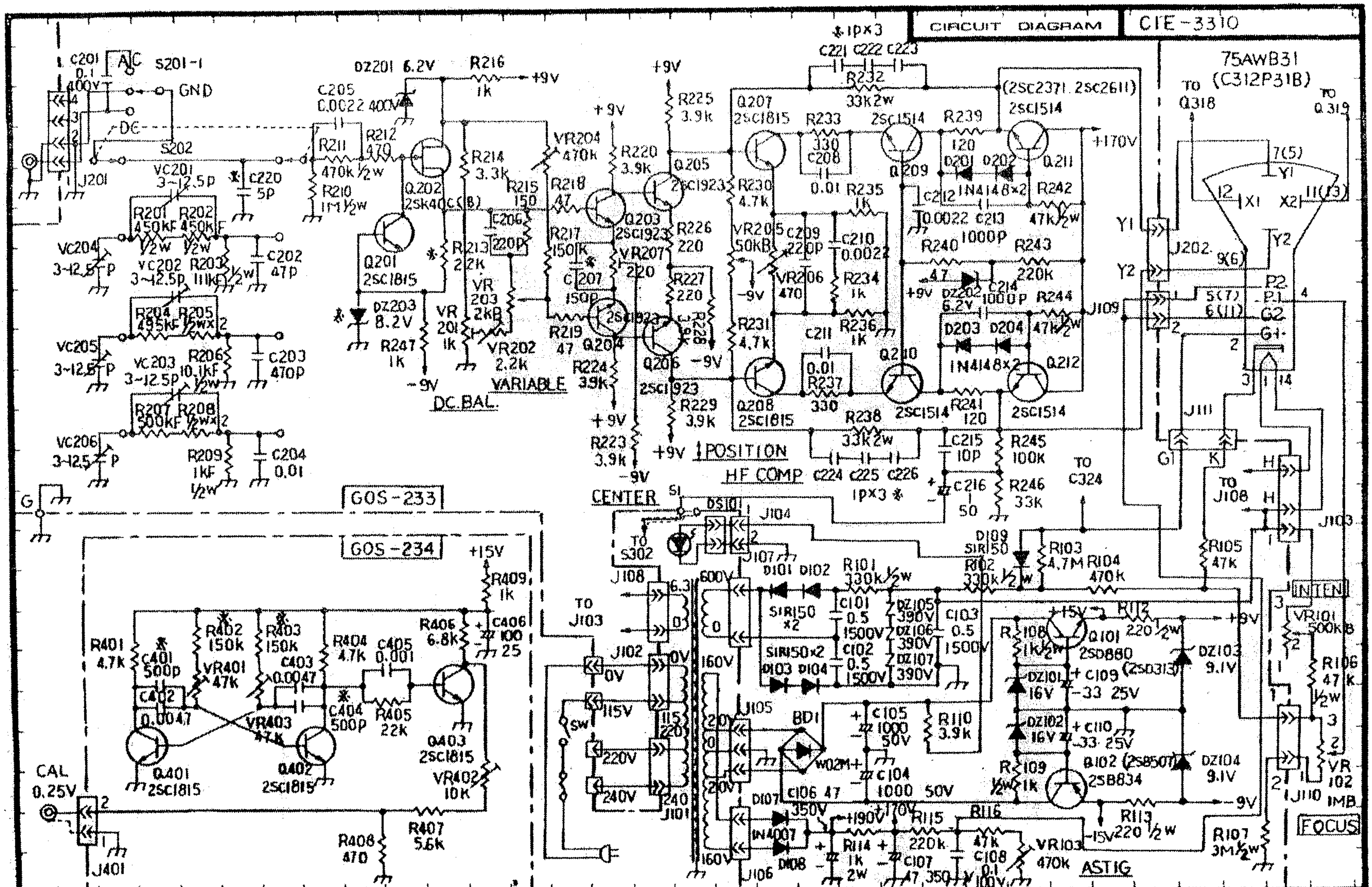
Table I

Calibrate Signal Adjustment

1. Calibrate Signal Frequency and Symmetry Adjustment
    1. Set the TIME/DIV switch to the 0.1mS range.
    2. Set the VOLTS/DIV switch to the 50mV/DIV range.
    3. Set the H.VARIABLE control fully clockwise.
    4. Connect the 0.25V CAL signal to the V. INPUT jack.
    5. Set the SLOPE switch to + (pushed in) and set the LEVEL control for a stable display.
    6. Adjust the H.POSITION so that the positive portion of the square wave begins on the left-most vertical graticule line.
    7. Adjust VR403 until the positive portion of the square wave is exactly 5 divisions long.

8. Adjust VR401 until the negative portion of the square wave is exactly 5 divisions long and the entire square wave is 10 divisions long. See Fig. 21 for control locations.

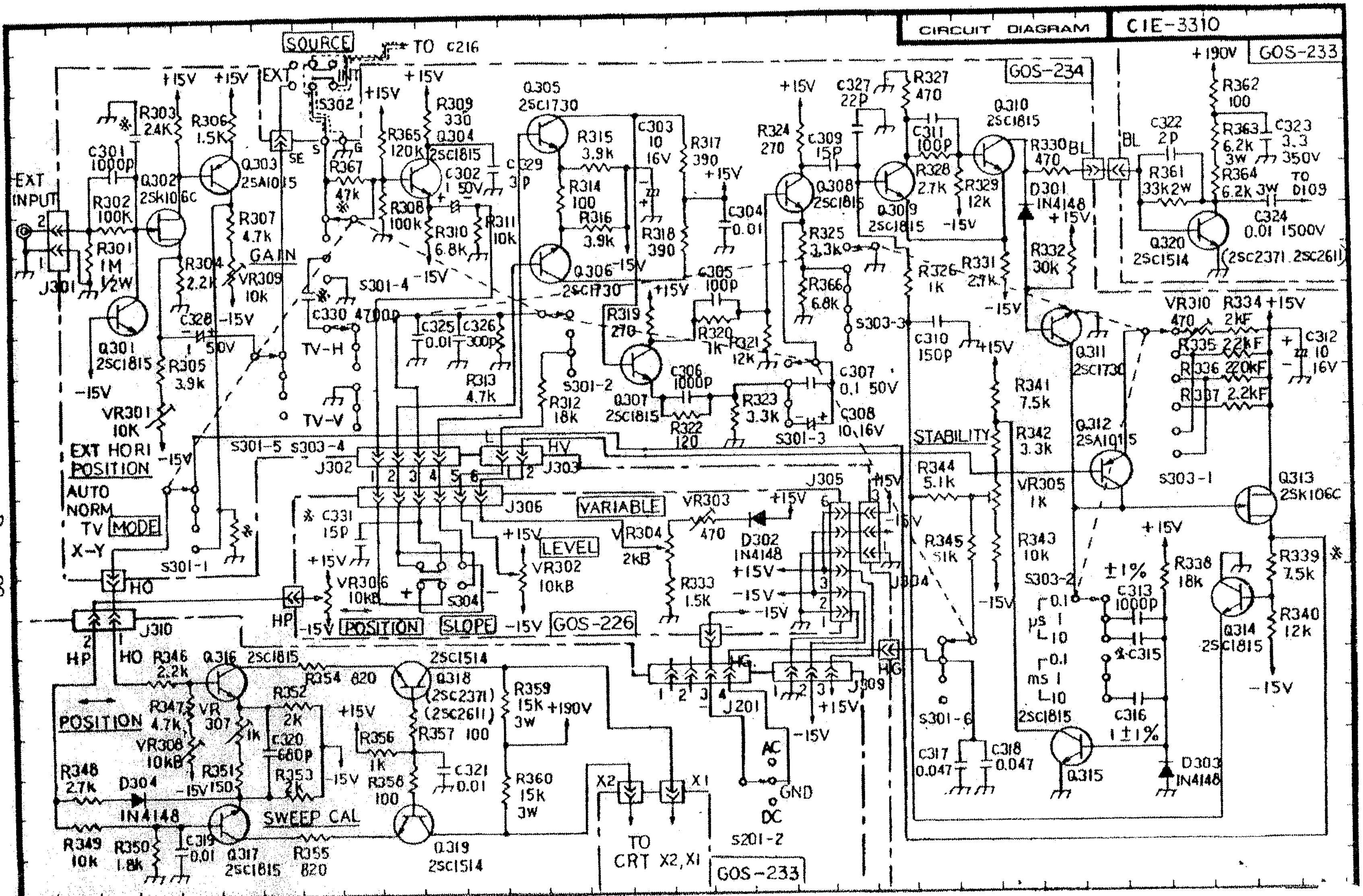
2. <u>Calibrate Signal Voltage Adjustment</u>
   1. Set up the scope controls like the calibrate signal frequency and symmetry adjustment above.
   2. Set the V.VARIABLE control fully clockwise.
   3. Adjust the 0.25V adjustment VR302 until the amplitude of the sqaure wave is exactly 5 divisions high. The correct calibrate signal with these scope settings is shown in Fig. 16.



Notes:

1. ※ - installed if needed
2. Resistance in ohms
3. Resistors ¼ watt unless specified
4. Capacitaces in μf unless specified

1. Vertical Amplifier and Power Supply



Notes:

1. ✻ - installed if needed
2. Resistance in ohms
3. Resistors ¼ watt unless specified
4. Capacitaces in μf unless specified

2. Trigger and Horizontal Amplifier Circuits